

American Fisheries Society Annual Meeting, Atlantic City, New Jersey, August 20-23, 2018

Symposium Title: **Aristotle's Mud to Modern Day: What Do We Actually Know About Catadromous Eels?**

Symposium Chair: Sheila Eyler, *U.S. Fish and Wildlife Service*

Symposium Abstract: Catadromous eels can be found world-wide and have been the focus of research directed to understand their life history and migratory patterns, monitoring programs to track the population status, and restoration programs to provide access past barriers and provide protection at hydroelectric facilities. Presentations in this session will cover a wide variety of the work centered around eels, including research on migration and life history, population surveys, and advancements in upstream and downstream passage technologies.

Presentations

1. Restoration of American Eel: A Brave New World?

Author: Paul T. Jacobson, *Electric Power Research Institute*

Abstract: The American eel (*Anguilla rostrata*) is a uniquely unique species in North America. It “occur[s] naturally in perhaps the broadest diversity of habitats of any fish species in the world”, encompassing more than 10,000km of coastline from Greenland to Venezuela (Helfman 1987); yet, catadromy (a unique trait among North American fishes) supports species-wide panmixia (another unique trait). The diversity of habitats is matched by the species’ ecological and behavioral variability and plasticity. The species is an ecological success; yet, depending upon the authority and jurisdiction, the American eel may be designated a species of concern, depleted, or endangered. How are restoration priorities to be established given the species’ geographic and ecological scope and potential for future recruitment declines? What are the population-level implications of alternative restoration actions? Are there trade-offs? Is an abundance of inland migrants a necessary condition for a robust population, a manifestation of a robust population, or both? Are eels vulnerable to an Allee effect? Our ability to answer these questions is compromised by the black box of American eel reproduction – who are the breeders and what is their relative fitness? Thus, a critical research need is to identify the spawning location(s) in the Sargasso Sea.

2. American Eel Management on the US Atlantic Coast over the Last 20 Years

Author: Kirby Rootes-Murdy, *Atlantic States Marine Fisheries Commission*

Abstract: Coordinated management of *Anguilla rostrata* through the Atlantic States Marine Fisheries Commission from Maine to Florida have changed in a number of ways since the approval of the Fishery Management Plan (FMP) in 1999. Management efforts over the last 5 years have allowed for the development of domestic glass eel aquaculture, a mechanism to trigger state allocations, and new constraints on coastwide landings to reduce fishing mortality across life stages. But these efforts have encountered challenges, both in implementation and demonstrating how 'successful' they've been in conserving the resource. During the last year management actions have focused on addressing these topics through a new addendum to the

FMP. Specifically, possibly expanding glass eel aquaculture opportunities, and potentially changing the landings limit for both yellow and glass eels/elver life stage fisheries. Understanding the lessons learned from these changes to American eel management over the last 20 years may provide other regions of the US, as well as other countries, important considerations as they seek to manage and conserve *Anguilla* species.

3. Assessing the Stock of American Eel: Past Results, Current Data Needs, and Future Goals

Author: Kristen A. Anstead, *Atlantic States Marine Fisheries Commission*

Abstract: American eels in territorial seas and inland waters along the Atlantic coast from Maine to Florida are managed by the Atlantic States Marine Fisheries Commission (ASMFC). The last benchmark stock assessment for American eel was completed in 2012 and updated in 2017. These stock assessments used landings data and fishery-independent survey data to look at trends regionally and coastwide. Both reports concluding that the American eel stock is depleted due to significant downward trends in multiple surveys, but the assessment still lacks a model that would allow for reference points, abundance estimates, or other outputs that would better inform the current management. Improvements in directed and detailed monitoring of the American eel population as well as the accuracy of the commercial catch has benefited the stock assessment, but many research and modeling needs remain as the ASMFC considers a future stock assessment.

4. Ecology and Conservation of the American Eel in the Caribbean Region

Authors: Thomas J. Kwak, *U.S. Geological Survey, North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University*; Augustin C. Engman, *North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University*; Craig G. Lilyestrom, *Puerto Rico Department of Natural and Environmental Resources*

Abstract: The American Eel *Anguilla rostrata* is a widely distributed, economically valuable, culturally significant, and ecologically important, but imperiled fish. Its distribution, biology, and ecology are reasonably well documented in the continental United States and Canada, but less so in the Caribbean, where it occurs on islands with permanent rivers, and Central and South American coastal rivers and freshwaters. We synthesized findings of original research on American eel distribution, abundance, population biology, habitat ecology, and threats from the Caribbean island of Puerto Rico. American eel were captured from 48 of 116 sites (41.4%) in 26 of 49 river basins (53.1%) during 2005–2016, and it was extirpated upstream of dams and migration barriers >3.0 m high (38.9% of habitat). Mean density and biomass were 438.9 fish/ha and 23.44 kg/ha, respectively. Upstream habitats favored larger individuals, and females were larger than males. The swim-bladder parasite *Anguillicoloides crassus* was not found in 120 eels examined. Realized threats include dams and migratory barriers, habitat loss and alteration, and pollution; exotic species and commercial fishing are impending threats; and the least understood is climate change. Our research findings enhance informed conservation and management of this widespread, but imperiled fish species.

5. Inventory of American Eels in Selected El Yunque National Forest Streams, Puerto Rico

Authors: Craig Roghair, *USDA Forest Service*; Colin W. Krause, *USDA Forest Service*; Jessica Ilse, *USDA Forest Service*; Andy Dolloff, *USDA Forest Service*; Kevin Leftwich, *USDA Forest Service*

Abstract: Prior to 2007, American Eels were considered to be present but scarce in Puerto Rico. Extensive island-wide surveys in 2007 and 2013 revealed that American Eels were much more widespread and abundant than previously believed, and that the highest densities of American Eels were in watersheds in the northeast corner of the island, on or adjacent to El Yunque National Forest. In 2014, El Yunque National Forest partnered with the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) to complete more extensive eel surveys in several watersheds. We selected sites in the lower and upper reaches of each watershed and used 3-pass depletion sampling methods to further describe eel distribution both within and among the 5 watersheds and to quantify relative abundance in watersheds known to contain American Eels. We collected eels from 9 of 14 sample sites. Eel density ranged from 0 to 1,984 eels per ha and size from 100 mm to 920 mm. Natural and manmade barriers to upstream fish passage clearly impacted distribution and abundance. Despite their disjunct distribution within the national forest, El Yunque has a clear role to play in conservation of the American Eel.

6. Current Research to Assess the Status of American Eel in Gulf Coast Drainages of Texas

Authors: Stephen Curtis, *Texas Parks and Wildlife Department*; Kevin Mayes, *Texas Parks and Wildlife Department*

Abstract: American Eel *Anguilla rostrata* is a remarkable species with a unique and complex life history that is fairly well-studied on the eastern coast of the United States. Efforts to better understand the population structure and life history of American Eel are underway in Gulf of Mexico and Caribbean drainages. In Texas, state and federal agencies, multiple universities and numerous citizen science volunteers are working to assess the status of American Eel to better inform conservation and management decisions. The primary objectives of our efforts are to assess the current and historical distribution and abundance, habitat use, movement patterns, parasite occurrence, diet and population structure (genetics, age, sex, etc.) of American Eel across all life stages. To help facilitate these objectives, project partners are conducting field sampling to collect all life stages of American Eel, organizing a state-wide citizen-science monitoring program with a concerted effort to capture glass and elver eels in tidal rivers and streams, and reaching out to fish enthusiasts (fisherman and scientists alike) for eel sightings and specimens from across the state. This talk will also cover ongoing American Eel passage studies associated with hydropower project relicensing.

7. Investigating American Eel (*Anguilla rostrata*) in Louisiana: A Preliminary Report on Data Collected Utilizing Standardized Sampling Bycatch

Authors: Robby Maxwell, *Louisiana Department of Wildlife and Fisheries*; Sean Kinney, *Louisiana Department of Wildlife and Fisheries*

Abstract: In the past few years, there has been increasing interest in American Eel (*Anguilla rostrata*) due to pressure on stocks from markets in Europe and Asia, impacts from passage barriers, habitat loss, possible effects of *Anguillacoides crassus* infections, and the lack of available life history information. Very little is known about Louisiana populations, so we applied and were approved for a two-year State Wildlife Grant to collect baseline population data on Louisiana populations of American Eels. We are utilizing bycatch from standardized sport fish sampling efforts across the state. Data collected from specimens includes length,

weight, diet, sex, age, gonad development, air bladder condition, presence of *Anguillicola crassus*, and tissue samples for suture analysis. Each sample also has a location, habitat data, and sampling method attached for further understanding of eel habitat usage. By the conclusion of the study, we will not only have a better understanding of eel populations in the state, but also information to inform future sampling efforts and American Eel research.

8. Rates of Apparent Survival and Habitat Covariates of Juvenile American Eels, *Anguilla Rostrata*, in North Carolina Tidal Creeks

Authors: Paul J. Rudershausen, *North Carolina State University*; Laura M. Lee, *North Carolina Division of Marine Fisheries*; Jeffrey A. Buckel, *North Carolina State University Center for Marine Sciences and Technology*

Abstract: Saltwater tidal creeks in the southeastern U.S. serve as habitat for juvenile American eels *Anguilla rostrata* but rates of survival of this life stage remain unknown here. Additionally, information is lacking on habitat usage and effects of development in western Atlantic estuaries. We trapped and PIT tagged juvenile eels in tidal creeks and then recaptured and autonomously re-sighted tagged individuals to estimate apparent survival and habitat/environmental covariates of catch. Generalized linear models (GLMs) were fitted to catch rates to determine habitat/physical covariates at both site- and creek-level spatial scales. Median annual apparent survival was higher when a Cormack Jolly Seber model was fitted to mark-resight data than mark-recapture data. Fitting of GLMs revealed that the presence of salt marsh as well as a common type of development that eliminates it - bulkheads - were negative covariates of catches while the presence of culverts was a positive covariate. To our knowledge these are the first estimates of apparent survival of juvenile American eels in southeastern U.S. estuaries. Urbanization of this coastal zone, the current stock status of American eels, and their long durations of residency in estuaries increase the urgency of estimating demographics, habitat preferences, and anthropogenic stressors in this region.

9. American Eel Recruitment, Demographics and Disease in Virginia

Authors: Troy D. Tuckey, *Virginia Institute of Marine Science*; Mary C. Fabrizio, *Virginia Institute of Marine Science*; Aaron J. Bunch, *Virginia Department of Game and Inland Fisheries*

Abstract: Recent investigations of American Eel (*Anguilla rostrata*) in the Virginia portion of Chesapeake Bay have focused on glass eel recruitment and yellow eel relative abundance, demographics, and disease status due to *Anguillicoloides crassus*. Glass eel recruitment has been monitored since 2001 in the Potomac, Rappahannock, York, and James River estuaries and the timing of arrival of glass eels at the monitoring sites is consistent with the distance of each site from the mouth of Chesapeake Bay. Relative abundance of glass eels varies by multiple orders of magnitude among sites and years. Yellow eel abundance has been monitored through a standardized trawl survey and relative abundance has declined since the late 1980s and remains below the historic average. Age composition of yellow eels taken from these same systems from trawl and electrofishing surveys from 2013 to 2015 range from age-0 to age-15 with most eels around three or four years old. Adult nematode prevalence in yellow eels averaged 46.2% and the annual survival rate of disease-positive eels was lower than that of disease-negative eels. Management of American Eel can be improved through further study of

eel population dynamics throughout its range in support of developing biological reference points.

10. American Eels in a Virginia Mountain Stream

Authors: C. Andrew Dolloff, *USDA Forest Service and Virginia Tech*; Craig Roghair, *USDA Forest Service*; Dawn Kirk, *George Washington and Jefferson National Forest*; Scott M. Smith, *VA Department of Game and Inland Fisheries*; Andy Strickland, *Florida Fish and Wildlife Conservation Commission*

Abstract: During routine sampling of headwater mountain streams in the late 1990s, we captured a higher than expected number of American Eels (*Anguilla rostrata*), spurring a series of studies that continue to the present day. Since the early 2000s, annual population estimates have ranged unpredictably from 7 upward to over 54 American Eels per ha. Radio telemetry tracking of 33 eels from July 2000 to July 2001 revealed average home ranges of less than 500m and use by individual eels of spaces under stream banks as winter habitat. During 18 consecutive annual mark and recapture samplings of a 2 km reach of South Fork Tye River, we have captured and tagged over 2000 individual eels, and recaptured nearly 50% at least once. Several individuals have been recaptured up to 9 times with a maximum of 16 years between tagging and first recapture. On average, recaptured eels were within 200 m of release location and grew 22 mm (23 g) per year. Our results suggest that American eels in mountain streams may occupy relatively short stream reaches over many years, and local habitat conditions may play a larger than expected role in maintaining populations.

11. Understanding the Ins and Outs of American Eel Migration in the Bronx River - CANCELLED

Authors: Merry Camhi, *Wildlife Conservation Society*; John Waldman, *Queens College*; Jake LaBelle, *Wildlife Conservation Society*; Michael Bednarski, *Virginia Department of Game and Inland Fisheries*

Abstract: The American eel *Anguilla rostrata* is an important catadromous fish species that is in sharp decline throughout its range. Dams remain a major impediment to eels penetrating the inland freshwaters that historically supported vast numbers of yellow eels. Over the past four years we have been investigating the fine-scale movements and densities of eels in the Bronx River, a heavily dammed and highly urbanized tributary to the Hudson River Estuary. We monitored the upriver penetration by young-of-the-year eels over a six-dam river reach (19 km). We used electrofishing surveys to capture 1033 eels, and PIT-tagged 322 to track yellow eel movements among nine river segments (30 km), and estimated eel sizes and densities within river segments. The area below the first dam above tidewater held large numbers of smaller eels (mean=216 mm TL), the second dam had moderate numbers of slightly larger eels (mean=307 mm TL), and the next five dams held few, but much larger individuals (mean=451–682 mm TL). Recapture of 48 tagged eels showed them to be highly stationary between collection dates and river segments. Eels reached the first seven dams despite an absence of eel passes; we speculate on mechanisms.

12. Tracking Eel Movements in the St. Lawrence River – a Collaborative Approach

Authors: Scott Schlueter, *U.S. Fish and Wildlife Service*; Alastair Mathers, *Ontario Ministry of Natural Resources*; Jean Caumartin, *Hydro-Québec*; Daniel Hatin, *Ministère des Ressources*

naturelles et de la Faune du Québec; Thomas Pratt, Fisheries and Oceans Canada; David Stanley, Ontario Power Generation; Dimitry Gorsky, US Fish and Wildlife Service; Justin Ecret, U.S. Fish and Wildlife Service; Paul T. Jacobson, Electric Power Research Institute

Abstract: A bi-national collaborative effort is underway to reduce turbine mortality of outmigrating American Eels from Lake Ontario and the St. Lawrence River system. Prior to testing an in-water guidance device, baseline data is needed to determine natural migration routes of eels in the areas of interest. Since 2015, 191 Vemco V13 tags have been surgically implanted in large yellow eels and the fish released into the Bay of Quinte. We have learned that the survival rate of the tagged fish has been high. In 2017, 49% of fish migrated and were detected passing the Iroquois Dam in the same year as tagged. In the same year, 32% of the fish passed Beauharnois Dam further downstream on the St. Lawrence River. Fewer eels were detected on the northern/western side of the channel at both the Beauharnois and Iroquois Dam study sites, respectively. In 2017, 68% of the eels passed through 43% of the eastern-most gates at Iroquois Dam indicating that the eels are not randomly distributed across the river channel. Overall, eels were successfully tracked with Vemco VPS technology and the results will be presented. In addition, the 2018 plans will be discussed.

13. The Long Journey: A Telemetry and Modelling Study of Migrations of American Eels from the Upper St. Lawrence River to the Sargasso Sea - CANCELLED

Authors: Martin Castonguay, *Institut Maurice-Lamontagne*; Mélanie Beguer-Pon, *Université Laval*; Shiliang Shan, *Bedford Institute of Oceanography*; Julian Dodson, *Université Laval*

Abstract: Oceanic spawning migrations of American eels have remained a mystery until the first direct observations were provided by recent tracking experiments. Trajectories of 17 eels equipped with satellite tags and tracked for 14 to 58 days over approximate distances of 630 to 2750 km were reconstructed. Thirteen eels were tracked beyond the continental shelf, including five eels into the Sargasso Sea. Similar trajectories were found: eels swam against currents towards the eastern part of the spawning area. Estimated net migration speeds in the open ocean ranged from 34.8 to 54.2 km.day⁻¹. In coastal waters, two vertical behaviours were observed: (i) repeated up-and-down movements within the top 50 m (ii) diel vertical migration with eels swimming to greater depths during daytime (down to 974 m). Eels tracked in the Sargasso Sea all exhibited diel vertical migrations. The daytime and nighttime migration depths could not be explained by physical factors examined. Some eels appeared to track isotherms. Eels tracked in the Sargasso Sea in 2014 ascended to depths shallower than 100 m at night while eels tracked in 2015 were deeper. It appears that neither the vertical swimming behaviour nor abiotic oceanic parameters play a major role in the eels' orientation mechanism.

14. Fate of Translocated American Eel (*Anguilla rostrata*) in the Lower Ottawa River

Authors: Nicolas Lapointe, *Canadian Wildlife Federation*; David Callaghan, *Canadian Wildlife Federation*; Lauren Stoot, *Canadian Wildlife Federation*; David Browne, *Canadian Wildlife Federation*

Abstract: American Eel (*Anguilla rostrata*) are considered endangered under the IUCN's red list. Hydropower facilities are the primary threat because they block juvenile upstream migration and kill adults during outmigration. Juvenile eels may be trapped and transported around barriers as a mitigation strategy. To understand the fate of transported eels, we monitored

post-translocation movements in a 110-km reach of the Ottawa River bounded by two hydropower facilities. Additionally, we assessed the searching behaviour of eels that reached the upstream barrier, a multi-channel facility. Forty juvenile eels were implanted with Vemco V7-4x acoustic transmitters in 2015 and 31 receivers were deployed. Eels were split into two groups released at lower and upstream sites within the reach. Of the 40 translocated eels, 78% remained above the lower barrier. Of the nine eels that dispersed downstream, seven were from the downstream release site; however, the proportion of dispersers did not differ significantly between release sites ($X^2 = 2.29$, p -value = 0.13). One eel passed the upstream barrier despite a lack of known passage routes. At the upstream barrier, eels spent significantly more time below the spillway than other barriers ($X^2 = 55.07$, p -value < 0.001), indicating a potentially suitable ladder location.

15. Preliminary Results from a Coastal Stocking Experiment Indicate Life-History Effects and Stocking Site Fidelity in European Eels (*Anguilla anguilla*)

Authors: Laura Wichmann, *State Research Center for Agriculture & Fisheries Mecklenburg-Vorpommern/ University of Hamburg*; Malte Dorow, *State Research Centre for Agriculture and Fisheries Mecklenburg-Vorpommern*; Jens Frankowski, *State Research Centre for Agriculture and Fisheries Mecklenburg-Vorpommern*; Björn Kullmann, *University of Hamburg*; Ralf Thiel, *University of Hamburg*

Abstract: The recruitment of the European eel stock has collapsed and stagnates at historical low levels. With the objective to support the stock, member states of the European Union were requested to elaborate eel management plans to ensure a minimum escapement biomass of at least 40 % compared to the pristine level. Most eel management plans include stocking measures in inland waters. To determine if stocking is also a management option in coastal waters, a stocking experiment with glass eels has been conducted in two different areas of the German Baltic Sea. In both areas, over 1 Million glass eels have been stocked between 2014 and 2016. To allow discrimination of stocked from natural recruits after recapture, all stocked eels were chemically marked with alizarin red S. In 2017, eels were captured with an eel-specific enclosure net system for non-tidal coastal areas. Preliminary results show that approximately 30 % of all investigated eels were marked which reveals high stocking site fidelity. Furthermore, in both stocking locations marked eels showed a significantly higher total length at the age 3+ compared to naturally recruited conspecifics which could indicate a life-history dependent growth pattern as previously observed in the American eel.

16. Well-Intentioned, but ... Lessons Learned from European Eel Stocking Measures

Authors: Björn Kullmann, *University of Hamburg*; Ralf Thiel, *University of Hamburg*

Abstract: Juvenile eel stocks have collapsed worldwide and the e.g. European eel stock is in a perilous state compared to the reference period between 1960 and 1979. Stocking is a key measure in numerous management plans across Europe to refill local eel stocks that chronically suffer from poor recruitment. Serious problems, however, hamper evaluations of a potential net benefit and the intended conservation character of stocking: (i) Yet, it is entirely reliant on wild catches while glass eels are massively subject to contraband trade, (ii) diseases screenings prior to stocking are not always legally obligated, and (iii) the missing traceability of stocked eels, particularly those pre-grown in farms prior to stocking, interferes with local stock

assessments and the evaluation of management measures. Since contraband is under jurisdiction of overstressed authorities, immediate improvement of eel stocking is limited to the local level. Based on an experimental approach with simultaneously stocked glass and farmed eel in the western Baltic Sea region, we uncover typical deficiencies in current stocking plans such as the almost impossible discrimination of stocked from natural recruits, related interference with ageing and growth calculations, and anthropogenic dissemination of diseases. A concrete course for prospective actions will be discussed.

17. American Eel Restoration and Monitoring in the Susquehanna River Basin

Authors: Aaron Henning, *Susquehanna River Basin Commission*; John Wiley, *USFWS*

Abstract: The American eel (*Anguilla rostrata*) was formerly a prominent component of the Susquehanna River Basin's fish community, constituting up to 25% of the assemblage's biomass and representing an important fishery resource for local communities. Migratory fish passage in the basin effectively ceased in the early 20th century as multiple large hydroelectric dams were constructed across the lower mainstem Susquehanna River. Since 2005, numerous entities have worked towards restoring the basin's American eel population, utilizing a variety of techniques and strategies. The principle mechanism has been through trap and transport of eels from below the first large dam in the basin to upstream areas in Pennsylvania. To date over one million American eels have been captured and transplanted in Pennsylvania, and New York recently approved stocking efforts in that state. Reported recapture data suggest transplants have thrived, distributing themselves widely to currently occupy at least 30% of the basin's HUC 10 watersheds. Upstream efforts to restore eels in the basin have focused on improving or providing fish passage at hydroelectric and non-power dams in both states. Inter-agency coordination and public-private partnerships have driven much of the success of the restoration program.

18. Sexual Differentiation and Growth of Re-Introduced American Eels in the Susquehanna River Watershed

Authors: Josh Newhard, *U.S. Fish and Wildlife Service*; Julie Devers, *U.S. Fish and Wildlife Service*

Abstract: American eel have been precluded from a majority of the Susquehanna River since the construction of four major mainstem dams in the early 20th century. Earnest attempts to increase eel abundance upstream of these dams began in 2008 via stocking and have continued to present. In Buffalo Creek, a small tributary in Pennsylvania, eels were stocked directly into the watershed at two main locations from 2010-2013. Beginning in 2012, we began a PIT-tagging program near stocking locations to monitor growth and movement of stocked eels. We have tagged over 1,600 eels greater than 200 mm total length and have recaptured 150 individuals with several individuals captured three times or more. As eels grew over time, we noticed sexual differentiation in captured silver phase males that were under 400 mm and/or yellow phase females that were over 400 mm. Females grew significantly faster than males. Average female growth rate was 77.0 mm per year (range: 47.7-116.7) while males only grew an average of 28.1 mm per year (11.3-41.8). Eels that were tagged but for which gender could not be determined grew an average of 40.6 mm per year (2.1-102.7).

19. An Overview of the Recently Constructed Upstream Eel Facility at the Conowingo Hydroelectric Station, Maryland

Authors: Michael Martinek, *Normandeau Associates, Inc.*; Ray Bleistine, *Normandeau Associates, Inc.*; Andrea Danucalov, *Exelon Generation Company*

Abstract: Concerns over declining American Eel *Anguilla rostrata* stocks have arisen in recent years and efforts to restore this species to historic habitats by providing eel facilities at hydroelectric stations have intensified. The Conowingo Hydroelectric Station is the first of four hydroelectric dams located on the lower Susquehanna River (River Mile 10) upstream of the Chesapeake Bay in Maryland. The recently constructed upstream eel facility is located on the powerhouse side of the river just below the turbine discharge. The entrance of the ramp is above the high water level in the tailrace and has a slope of approximately 43° with a length of nearly 29 ft. The facility is operated from early May to mid-September, annually. In 2017, this facility collected 122,300 juvenile American Eel with an average size of 122 mm. The recently constructed facility was modeled after the general design guidelines with input from regional resource agencies and Exelon, the power company that owns Conowingo Hydroelectric Station.

20. Wow, That's a Lot of Eels! But Is It Enough?

Authors: Bob Graham, *Dominion Energy*; Peter Sturke, *Dominion Energy*; Corey Chamberlain, *Dominion Energy*

Abstract: The Roanoke Rapids/Gaston Hydropower Project includes the first two dams on the lower Roanoke River in North Carolina that are obstacles to diadromous fish. As part of relicensing the project, in 2004 the National Marine Fisheries Service issued a fish passage prescription that included American Eel. In 2010 upstream passage was established via trap and transport at three facilities of varied construction at Roanoke Rapids, the lowermost dam on the Roanoke River. A requirement of the passage program was to evaluate the effectiveness of the facilities. Four measures of effectiveness were examined during the first two years of operation. The measures focused on the proportions of eels that found the eelways and entered them, that traversed the eelways to holding tanks, that were being passed safely, and the proportion of passed eels that fell back to the Roanoke River. Study results indicated the three eelways varied in their effectiveness at passing eels. Similarly, the adequacy of the studies to evaluate effectiveness varied. Despite variability in eelway effectiveness and study design, the upstream passage program for American Eels has been judged successful. Since 2009 over 2 million eels have been provided safe upstream passage.

21. O Rostrata, Rostrata. Where for Art Thou, Rostrata?

Authors: Peter Sturke, *Dominion Energy*; Bob Graham, *Dominion Energy*; Corey Chamberlain, *Dominion Energy*

Abstract: As part of an American Eel upstream passage program at Roanoke Rapids Dam on the lower Roanoke River, Dominion Energy implemented several programs to track the movements of eels passed upstream of the dam via trap and transport. Upstream passage began in 2009 and has continued annually. The numbers of American Eels transported and released has varied annually from 2,622 to 814,101. A small proportion of the eels were implanted with individually coded wire tags from 2009 - 2012. Transported eels were released to two sites in approximately equal numbers – a site in the upstream impoundment, Roanoke Rapids Lake, and a site in the

only major tributary to the lake, Deep Creek. Three sampling programs and an experimental study have been used to track the movements of the eels. In conjunction with the Pacific Northwest National Laboratory, a study of elver movements in Deep Creek was conducted in 2017 that utilized experimental acoustic micro-transmitters. With the exception of the traps at the next dam upstream, relatively few eels have been recaptured as part of the various survey programs employed. Trapping at Gaston Dam was similarly relatively ineffective until the last few years, when trap catches have increased nearly exponentially.

22. Ecology of American Eel in the Roanoke River Above and below a Hydroelectric Dam

Authors: Jesse R. Fischer, *North Carolina State University*; Thomas J. Kwak, *U.S. Geological Survey, North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University*; Carl W. Hintz, *North Carolina State University*; R. Wilson Laney, *U.S. Fish and Wildlife Service*

Abstract: American Eel *Anguilla rostrata* populations in reservoirs comprised of previously transported elvers are potentially well suited to experience altered life history characteristics relative to riverine populations due to density-dependent sex determination and sexual differences in growth. Transportation of American Eel elvers from the Roanoke River to Roanoke Rapids Lake began in 2009 and over 2 million eels have been relocated to date. Our objective was to describe and compare lentic and lotic dwelling American Eels from below and above Roanoke Rapids Dam to characterize population-level effects of relocation. A total of 281 eels from reservoir and riverine habitats was sampled to describe size, sex, and age structure, estimate condition and growth, and determine the prevalence of the invasive parasitic swimbladder nematode *Anguillicola crassus*. Overall, size, age structure, condition and growth differed between lentic and lotic habitats, while sex ratios and percentage of eels infected with *A. crassus* were similar. Evidence of earlier maturation in the reservoir may be suggested from our results as the first silver-phase female eel (410 mm TL, age 5) was sampled in 2016. Our findings provide a greater understanding into the ecology of American Eel that is necessary guide the management and conservation of migratory populations.

23. It Truly Takes a Whole Village: Collaboration by Agencies and Industry to Restore American Eels to the Upper Roanoke River Basin

Authors: R. Wilson Laney, *U.S. Fish and Wildlife Service*; John Ellis, *U.S. Fish and Wildlife Service*; Fritz Rohde, *National Marine Fisheries Service*; Jeremy McCargo, *North Carolina Wildlife Resources Commission*; Kirk Rundle, *NC Wildlife Resources Commission*; Todd Mathes, *NC Division of Marine Fisheries*; Dan Michaelson, *Virginia Department of Game and Inland Fisheries*; Scott M. Smith, *VA Department of Game and Inland Fisheries*; Bob Graham, *Dominion Energy*; Peter Sturke, *Dominion Energy*; Corey Chamberlain, *Dominion Energy*; Karen Canody, *Dominion Energy*

Abstract: Implementation of Federal Energy Regulatory Commission (FERC) hydropower licenses can present difficulties for both the licensee and resource agencies responsible for ensuring that implementation achieves the natural resource enhancements intended. Nearly 300 FERC hydropower relicensings will occur in the next 10 years; therefore, cooperative efforts among stakeholders and strategies to deal with extenuating circumstances that can delay or derail license milestones should be shared to help ensure productive efforts in the future.

Dominion Energy, state and federal agencies (collectively the Diadromous Fish Restoration and Technical Advisory committee (DFRTAC)) have worked in a cooperative manner to implement the license for Roanoke Rapids Power Station as unexpected issues that could have hampered successful completion of license requirements were encountered. While most of this group's early work focused on American Eel and American Shad restoration, the relicensing process that initially brought the stakeholders together has resulted in broader multi-species efforts that include river and floodplain continuity concerns. The agencies and Dominion Energy have been able to secure funding for studies that expanded the scope of resource enhancement required of the company. Regular meetings and communications with an open attitude to outside knowledge allow the DFRTAC to work in an adaptive manner.

24. Dam Influences on Habitat Use and Migratory Survival of American Eel in the Penobscot River, Maine

Authors: Joseph Zydlewski, *U.S. Geological Survey: Maine Cooperative Fish and Wildlife Research Unit*; Kevin Job, *University of Maine*; Erik Blomberg, *University of Maine*

Abstract: In the Penobscot River, Maine, main-stem dams (e.g., West Enfield and Milford Dams; river km 99 and 62) remain sites of American eel passage concern. Dams impede the upstream juvenile migration but successful migrants may face significant life history costs. We sampled sub-adult and adult American eel upstream of Milford Dam (n=46) and sub-adults downstream of the dam (n=42). Otoliths were used for aging, growth, and microchemical analysis. Upstream fish grew slower than downstream fish with reduced estimated lengths at age. Patterns of otolith Sr and Ba indicate that downstream fish had complex patterns of fresh water and saline habitat use while upstream fish were dominated by a freshwater signal. In 2016 and 2017, migrating silver eels (n=200) from a tributary of the Penobscot River were implanted with acoustic tags and released upstream of Milford and West Enfield dams. Nearly all fish exhibited directed downstream behaviors, but were delayed at the dams. Mortality through both dams was high (13 to 18%). These data suggest that American eels that successfully pass dams as juveniles are limited with respect to estuarine habitat access, likely resulting in slower growth and delayed maturation. As migrating adults, dams cause delay and direct mortality.

25. Downstream Eel Passage Routes through Three Successive Hydroelectric Dams on the Connecticut River, Fall 2015

Authors: Adam C. Slowik, *Normandeau Associates Inc.*; Drew G. Trested, *Normandeau Associates Inc.*; Steven D. Leach, *Normandeau Associates, Inc.*; Douglas Royer, *Normandeau Associates, Inc.*

Abstract: The downstream emigration of silver-phase American Eels, *Anguilla rostrata*, was evaluated during the fall of 2015 at three consecutive hydroelectric projects located on the main stem of the Connecticut River. We evaluated downstream passage route selection at these facilities in relation to the current operating conditions (i.e., the available flow through each passage route). Passage was monitored using fixed station radio telemetry equipment deployed at each route, the tailrace, and forebay. Overall, 170 telemetered eels were released and 154 (90.5%) of those individuals emigrated past their intended project. Of the 50 eels released into the most upstream Wilder impoundment 90% passed. Of the 50 eels released into

the Bellows Falls impoundment 94% passed. Twenty (100%) additional eels passed Bellows Falls when released directly into the power canal. Of the 50 eels released into the downstream most Vernon impoundment 86% (43 eels) passed. The dominant route of passage at each project was the turbine units. An analysis of each of the three projects demonstrated that the route with the highest proportion of river flow (amongst all available various routes) was the route with the highest passage (Wilder, turbines 1&2, 78.6%, Bellows Falls turbines 1-3, 80.2%, and Vernon, turbines 5-8, 61.4%).

26. Demographics of American Eel Collected in the Commercial Weir Fishery in the Upper Delaware River, NY

Authors: Jessica Best, *New York State Department of Environmental Conservation*; Sheila Eyler, *U.S. Fish and Wildlife Service*

Abstract: The only commercial American eel weir fishery in the U.S. occurs in New York in the upper Delaware River. To better understand the demographics of the harvested population of eels, we sampled commercial catch from four different weirs from August through November 2017. A total of 327 eels were collected, with some males present in the landings although most (95%) were female. Average total length was 557 mm for females and 370 mm for males. Average weight was 340 g for females and 88 g for males. For female eels, the Pankhurst's Eye Index averaged 8.77 and the Pectoral Fin Index averaged 5.04. The GSI for female eels averaged 2.82. The majority of stomach contents were empty of the eels collected. Sampled eels had between 0 and 40 swim bladder nematodes present with an average of 4 nematodes per eel for females and 2.7 nematodes per eel for males. Based on Eye Index and GSI, most eels were likely silver or in the process of silvering at the time of collection, but determining maturity stage based solely on external coloration was difficult as nearly all captured eels were dark in coloration with many having some degree of yellow pigmentation.

27. Silver-Phase European Eel (*Anguilla anguilla*) Biology and Conservation in Ireland

Authors: T. Kieran McCarthy, *National University of Ireland, Galway*; Eamonn S. Lenihan, *National University of Ireland, Galway*; Colin Lawton, *National University of Ireland, Galway*

Abstract: The decline of the European eel stock has been of serious concern throughout the continental range of the species and member states of the European Union are required to implement Eel Management Plans (EMPs) that seek to restore the stock to a sustainable level. In Ireland, the national EMP has specified a number of conservation measures, including closure of all eel fisheries, and facilitated eel population research. In this review we outline the approach adopted for mitigation of adverse effects of hydropower on seaward migrating pre-spawner eels. We will describe a large scale trap and transport programme and illustrate how monitoring this conservation action is used in estimation of silver eel production and spawner biomass escapement. We will also describe how new protocols are being developed for investigation of silver eel biology in Irish rivers. Use of acoustic cameras, removal fishing techniques and modelling using catch data from conservation fishing sites are among the new protocols that are improving our understanding of migrating silver eels in Irish hydropower regulated rivers.

28. Shattering the Glass Eeling: How Eels Engage New Audiences through Citizen Science

Authors: Christopher H. Bowser, *New York State Department of Environmental Conservation & Cornell WRI*; Sarah J. Mount, *NYSDEC & New England Water Pollution Control Comm.*; Grace Ballou, *Hudson River National Estuarine Research Reserve & Hudson River Estuary Program*

Abstract: Projects with trained “citizen scientists” are growing in popularity, but skepticism about scientific rigor challenges volunteer monitoring. The ecology of juvenile American eels and the established methodology of monitoring them make this species ideal for citizen science. New York’s “Hudson River Eel Project” has maintained a decade of data collection by 750 annual participants, from high school students to retirees, at 13 sites along 130 miles of estuary. Some students have even gone on to pursue environmental degrees and professions. Volunteer efforts have the capability of expanding the spatial, temporal, and cultural reach of fish conservation. There is need for more long-term monitoring of eels and this project, including the catch and release of 550,000 glass eels, provides invaluable data that have management applications. We will discuss methods and protocols used in New York to ensure volunteer-generated data are high quality, and we will describe how ten years of data are being used to support restoration efforts. We will also describe what conditions are ideal for community science of any topic, and how to keep a highly diverse group of participants engaged and dedicated.